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Forest Pest Management
Report No. S98-2

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Evaluation of Forest Pest Conditions on Los Coyotes Indian Reservation San Diego County, CA

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Summary

Forest pest conditions on the Los Coyotes Indian Reservation are reviewed. The mixed conifer forest on Hot Springs Mountain is generally in good condition. Insects and pathogens which could cause significant losses are discussed, including annosus root disease, Armillaria root disease, true and dwarf mistletoes, the western pine beetle and related species, pine and fir engraver beetles, and the California flatheaded borer. Within the developed campground on San Ysidro Creek, trees are declining and some may fail, possibly causing death, injury, or property damage. Hazard tree mitigation and management of soil compaction, western pine beetle, and dwarf mistletoe within developed campgrounds are discussed. The danger of tree failure in this campground is currently the most serious forest health problem on the Reservation.

Introduction

On February 20, 1997, James Allison, Laura Merrill, Gil Stuart (BIA Forester) and Frank Taylor (then Spokesperson, Los Coyotes Band of Mission Indians) visited some sites on the Los Coyotes Indian Reservation in San Diego County, California, to evaluate forest health conditions. Los Coyotes Indian Reservation is located in north central San Diego Co. and is surrounded on three sides by the Cleveland National Forest and Anza-Borrego Desert State Park. The reservation includes Hot Springs Mountain (elev. 6,535 feet), the highest peak in San Diego Co. The lower elevations are open oak savanna/ woodlands, while the upper elevations are mixed conifer forest.

We visited a developed campground at the oak savanna - mixed conifer interface on San Ysidro Creek, then drove up to the abandoned fire lookout on top of Hot Springs Mountain. The upper elevations of the reservation are used to some extent for dispersed recreation (camping and hiking) and personal Christmas tree cutting.

Observations

The developed campground is at about 4,500 feet elevation and has very large old canyon live oak and Coulter pine. In the summer there are typically 70 visitors each weekend. There were no barriers to control vehicle movement within the campground. The trees were in a declining state of health, and there were no seedlings or saplings within the campground to provide replacements for dying overstory trees. A heavy snow a few months prior to our visit had broken many branches which had been left on the ground for use by campers. The oaks had extensive heart rot, and one large old canyon live oak, in particular, appeared particularly hazardous because of its location in the campground and the amount of decay visible through branch stubs. One two foot diameter Coulter pine appeared to be under current attack by the western pine beetle and was infected with dwarf mistletoe. Another Coulter which was approximately 55 inches in diameter at breast height had a dead top and was being used as a granary tree by acorn woodpeckers. Pitch masses characteristic of those made by the sequoia pitch moth and similar moth larvae were extruding from acorn woodpecker storage holes in the upper part of the live bole. The soil appeared to be compacted.

Hot Springs Mountain is covered with a diverse mixed conifer forest, including black oak, white fir, incense-cedar, sugar pine, Coulter pine, and Jeffrey pine. Pests - including true mistletoe on white fir, engraver beetles on white fir, and probable Armillaria root disease - were present at low levels. There appeared to be too much white fir regeneration and excessive fuels in certain locations, but in general the forest appeared to be in excellent condition.

Management considerations - mixed conifer forest

It is an error to assume that a healthy forest is only comprised of vigorously-growing live trees. Dead standing and down trees are essential for many wildlife species, including insects such as ants which prey on phytophagous insects, thus helping to regulate pest populations. Declining trees and the insects and disease organisms which prey on them are also part of a healthy forest, and should only be defined as *pests* when their activities interfere with the land owner's or manager's planned use of the forest.

Thus management of the tree debilitating or killing organisms should be predicated on their interference with management objectives. In a forest under management for ecosystem health, the goal should be to minimize anthropogenic disturbance, e.g., resulting from fire suppression or the invasion of exotic pests. In a forest under management for recreation, goals might include maximizing tree vigor and managing for hazard trees, particularly along roads and at high use sites. Note that in addition to oaks with heartrot, which is usually visible through branch stubs or wounds on the main bole, mature white fir in southern California frequently have heart or root rot, not visible, which can cause them to break or be wind thrown.

Annosus root disease. This disease, caused by the fungus Heterobasidion annosum, is probably the most serious forest pest in southern California. Both the p-type, which infects pine, incense cedar, and many hardwoods, and the s-type, which infects true fir, giant sequoia, Douglas-fir, and a few other genera, have been found on Palomar Mountain and thus can be expected to occur on Hot Springs Mountain. Infection usually occurs when spores land on freshly cut stumps, colonize the stump, and infect live trees through root grafts. True fir may become infected when spores land on basal wounds. Once established, the fungus can persist in woody debris in the soil for decades, infecting and killing host trees with which it comes in contact and creating characteristic openings in the forest. It is thought that this disease has become much more prevalent in this century in southern California because of tree cutting activities. In fir and other non resinous species this disease can decay the roots to such an extent that green trees may be wind thrown.

Prevention of annosus infection involves treating freshly cut conifer stumps with borate compounds (Sporax is currently registered in California for this use) and preventing logging injuries in true fir. In southern California, we recommend that *all* conifer stumps be treated. Stumps must be cut off evenly so that there are no jagged or vertical surfaces to which the borate compound would not adhere. A small amount (e.g., 1 oz. on a 20" diameter stump) of the borate compound is sprinkled over the surface. The importance of stump treatment cannot be overstated. Once established, root disease centers may persist for 50 years, with both regeneration within the center and mature trees on the periphery continuing to die. The presence of annosus root disease centers severely restricts the options for managing a stand.

Armillaria root disease. The Armillaria fungus is widely distributed in soils and typically lives as a decay organism in the roots, lower boles, and stumps of dead or living trees. Virtually all woody plants in California are hosts, but the fungus is most frequently associated with oak roots. Healthy oaks are resistant to the fungus, but if injured, weakened, stressed, or killed, the fungus rapidly colonizes the oak roots. With a large food base, the fungus becomes more aggressive and moves to the roots of nearby trees, particularly conifers. If it reaches the root collar it girdles the stem of the conifer and kills the tree. Thus preventing losses to this fungus involves maintaining oaks in healthy growing conditions.

Dwarf mistletoe. Management of dwarf mistletoe, Arceuthobium spp., ranges from expensive surveying and pruning of infected trees to selective cutting and the creation of buffers. See pest biologies section for an understanding of the epidemiology of this parasite. High value trees, such as those in campgrounds, may be rated using established methods (the Hawksworth rating system) and pruned or removed as appropriate. Should the tribe decide to do a mistletoe control program, James Allison should be contacted for assistance.

Two species of dwarf mistletoe are likely to be found on Hot Springs Mountain, A. campylopodum (hosts: Coulter, Jeffrey, and ponderosa pines) and A. californicum (host: sugar pine). Spread is primarily through the ejection of seeds in a cone shaped pattern

around the female mistletoe plant. Thus to minimize the debilitating effects of this pest outside of developed campgrounds, the best option is often to remove the most heavily infected trees (especially when the infection is in the upper crown and/or in the bole) and create buffers between infected stands and adjacent, uninfected but susceptible trees. Buffers could consist of open space or of plantings of tree species which are not susceptible to the dwarf mistletoe species present.

True mistletoe. Because true mistletoe, Phoradendron spp., is mostly a water parasite on true fir and hardwood species, it is not as severe a stressor as dwarf mistletoe. Heavily infected trees are weakened, reduced in growth and sometimes killed if other stressors or drought are present. Removal of the mistletoe plants through pruning of infected limbs reduces the stress to the host tree. If the level of infection in a tree is severe, the entire tree may be removed. However, true mistletoe is very expensive and difficult to control in forest stands, and control is usually only attempted on high value trees such as those in campgrounds. Local elimination of the parasite does not protect the stand from further infection. Birds, which eat the mistletoe berries, will reintroduce the parasite from nearby infected areas. About 5 to 10 years are required, however, for the parasite to build up to damaging proportions before control is necessary again.

Tree killing bark beetles. The western pine beetle, Dendroctonus brevicomis, is the most significant tree killing bark beetle in the mountains of San Diego Co., where the primary host is Coulter pine, although ponderosa pine may also be attacked. Normally this insect breeds in overmature trees, trees with dead tops or other severe injuries, trees with dwarf mistletoe, root rot, and other debilitating conditions. However, when populations become epidemic, such as in times of drought, even vigorously growing trees are attacked, as occurred in Lost Valley and to some extent on the Los Coyotes Indian Reservation in the late 1950s (Hall 1958). The only effective control for this insect is to prevent the buildup of destructive populations by maintaining proper stocking levels and managing other pests, such as root disease, dwarf mistletoe, and pine engravers.

The red turpentine beetle, D. valens, rarely kills trees. This beetle attacks stumps, roots, and the bases of fire-injured and otherwise debilitated trees. In times of drought attacks may be heavy, extend up the bole, and enough tissue may be damaged for the tree to be killed.

The mountain pine beetle, D. ponderosae, is less common in San Diego Co. than either of the two previous species. It may be found killing ponderosa, sugar, and occasionally pinyon pine. One other pine killing Dendroctonus sp., D. jeffreyi (which attacks Jeffrey pine) is thought to not occur in this area.

California flatheaded borer. Melanophila californica is an important cause of mortality of mature pines in southern California. Jeffrey and ponderosa pines are preferred hosts, but this beetle will also attack sugar, Coulter, and other pines. The California flatheaded borer is the most destructive insect in overmature, drought stressed, or debilitated Jeffrey pine in San Diego County. Some losses to this insect will always occur, but maintaining

a healthy forest at a proper stocking level is the most effective means of reducing losses to this pest.

Pine engraver beetles. Bark beetles in the genus Ips, particularly I. paraconfusus and I. pini, breed in broken branches and logging slash and in certain conditions kill small diameter trees or tops of mature trees. Proper treatment of logging slash is important in preventing losses to this pest (see Appendix B, "Guidelines for treating slash to reduce risks of engraver beetle outbreaks.")

Fir engraver beetle. Scolytus ventralis is a non aggressive bark beetle which feeds in true fir. Trees weakened by root disease, mistletoe, and/or drought are frequently attacked and top killed or killed outright, often in conjunction with other secondary insects, such as the roundheaded fir borer, Tetropium abietis. Prevention of losses associated with this insect involves proper management of other pests. However, because of fire suppression, white firs, which are shade tolerant, are now much more abundant in southern California forests than they once were, and pests of white fir may not necessarily be pests to the forest manager.

Management considerations - developed campground

Hazard trees. At the time of our visit, trees in the campground were declining. Left untreated, mortality among the pines will continue, and the oaks are at risk of failure and could injure or kill a person or damage vehicles or other property. At a minimum, a hazard tree program should be developed. This would entail numbering each oak tree and making a written record of its condition, and dealing with trees which present a hazard. Normally, hazardous trees - trees at risk of failing onto a target (a campground user, a vehicle, or a structure) - are pruned or felled to reduce the hazard. Fences to exclude visitors from parking or camping under hazard trees could also be used, if visitors do not ignore the fences. James Allison can assist with advice on a hazard tree program.

Soil compaction. Secondly, soil compaction is likely to be impacting the health of both the pines and the oaks and should be managed. Barriers to channel and control vehicular movement would be most effective. However, barriers should be used which will not provide nesting sites for ground squirrels, which can reach high populations in campgrounds and carry plague. See Pest Biologies section for more information on managing ground squirrels. Once barriers are in place, aerating the soil may improve the health of the live trees.

Dwarf mistletoe management. After prevention and reduction of soil compaction, removal of dwarf mistletoe from infected pines would have the second largest positive impact on their health and longevity. Dwarf mistletoe is both a water and nutrient parasite, and infected trees are far less able to resist bark beetle attack. Contact James Allison for assistance with a dwarf mistletoe management program including funding.

Bark beetle prevention. Prevention of pine mortality associated with bark beetles primarily involves maintaining the trees in a vigorous state of health by managing other agents (such as soil compaction, dwarf mistletoe, or root disease), maintaining appropriate stocking levels, and practicing good sanitation. Broken pine branches or logging slash left in the area may serve as breeding material for pine engraver beetles, which may move to tops of live pines and kill them, as well as attacking smaller diameter regeneration. See Appendix B for best sanitation practices. The western pine beetle was active in the campground at the time of our visit. This insect can develop high populations on declining trees and successfully attack and kill even vigorously growing trees. The boles of high value trees, such as those in campgrounds or around residences, can be sprayed with a pesticide registered for that use to prevent successful bark beetle attack while stressors (soil compaction, dwarf mistletoe) are dealt with. Insecticidal treatment of pine boles is not a long term solution and should only be used to buy time to deal with other problems affecting the health of the tree. Trees being used as mast trees by acorn woodpeckers should not be sprayed.

Conclusions

The mixed conifer forest on Hot Springs Mountain is in good condition. Management activities, such as tree cutting, which are undertaken should be done in a manner that will minimize the potential for the buildup of damaging pests. A simple approach to maintaining a healthy forest is to thin as needed to maintain appropriate stocking levels, and to treat all fresh conifer stumps with borate compounds to prevent annosus root disease. When stands are thinned, trees which are infected with dwarf mistletoe, particularly in the upper crown or the main bole, should be selected against. Care should be exercised in cutting oaks, as adjacent conifers may subsequently be killed by Armillaria root disease. Should the Tribe choose to not engage in management activities in the forest, losses to drought and pests may be expected to occur as the basal area of the stands increases.

The trees in the developed campground are in a serious state of decline and some present a hazard to people or property which could be struck by falling limbs. Should the Tribe wish to keep the campground open, it would be prudent to mitigate the hazard of the rotted oaks. Further actions could be taken to enhance the health of the trees in the campground and thus maintain the attractiveness of the environment. The most beneficial of these actions would be to reduce soil compaction through control of vehicle movement. Control of dwarf mistletoe in the campground would also increase the longevity of the pines. Contact Laura Merrill if further assistance with bark beetle control is needed.

Reference cited

Hall, R.C. 1958. Forest insect conditions, Lost Valley, Cleveland National Forest, Reconnaissance survey, Spring, 1958. USDA - FS, Calif. Forest and Range Exp. Sta., Division of Forest Insect Research, unnumbered report dated July 15, 1958. 3pp.

APPENDIX A

PEST BIOLOGIES

USDA Forest Service
Forest Pest Management, Region 5

Annosus root disease

Heterobasidion annosum is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (Arbutus menziesii), and a few brush species (Arctostaphylos spp. and Artemisia tridenta) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all the National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Annosus root disease is one of the most important conifer diseases in the Region. Current estimates are that the disease infests about 2 million acres of commercial forest land in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and in recreation areas, depletion of vegetative cover and increased probability of tree failure and hazard.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds or occasionally, through roots of stumps in the absence of surface colonization. The fungus grows down the stump into the roots and then spreads via root contacts into the root systems of adjacent live trees, resulting in the formation of enlarging disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion annosum in western North America consists of two intersterility groups, or biological species, the 'S' group and the 'P' group. These two biological species of H. annosum have major differences in host specificity. All isolates of H. annosum from naturally infected ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense-cedar, western juniper, pinyon, and manzanita have, to date, been of the 'P' group. Isolates from true fir and giant sequoia have been of the "S" group. This host specificity is not apparent in isolates from stumps, with the 'S' group being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may

survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Armillaria root disease

Armillaria sp. is widely distributed in soils and usually lives as a saprophyte on dead wood or other organic matter. This fungus has a wide host range, including virtually all woody plants in California. It is frequently associated with hardwood roots, especially oaks. Healthy oaks are resistant to the fungus. This resistance disappears, however, when trees are weakened, stressed, cut, or killed, and Armillaria sp. may then rapidly colonize and decompose roots and sometimes entire root systems. Stresses that have been linked to increased damage from this root disease include insect defoliation, drought, excessive soil moisture, poor planting techniques, bark beetle attack, air pollution injury, and nutrient deficiencies.

The organic material used as a source of nutrition is called a food base. With a large food base to utilize, the fungus becomes more aggressive and moves to the roots of nearby trees by means of root contacts and rhizomorphs. Rhizomorphs are structures that resemble black shoestrings and grow like roots through upper soil layers. The predominant method of tree to tree spread in California is via root contact; rhizomorphs are more important and prevalent in other areas of the country.

Armillaria sp. is capable of directly penetrating through the intact root bark of living trees and once it reaches the cambium it usually grows rapidly, producing a flat, white, leathery, fan-shaped mycelial mat. Rhizomorphs are often associated with the mat. If the fungus reaches the root collar it girdles the stem and kills the tree. After Armillaria sp. successfully colonizes a root segment or root system, it continues to decay the wood and causes a white to yellowish, wet, stringy rot. This rot does not usually extend more than a few feet above the soil line.

Clusters of mushrooms may be found in the fall at the base of infected dead or dying trees and stumps. These mushrooms may also grow directly out of the soil near the food base. Spores produced by fruiting bodies are not an important source of new infections or long distance spread.

Dwarf mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts. Western dwarf mistletoe (A. campylopodum) infects principally ponderosa, Jeffrey, and knobcone pines, and occasionally Coulter and lodgepole pines.

Dwarf mistletoes spread by means of seed. In the fall the fruit ripen and fall from the aerial shoots. The seeds are forcibly discharged. The seed is covered with a sticky substance and adheres to whatever it contacts. When a seed lands in a host tree crown, it usually sticks to a needle or twig, where it remains throughout the winter. The following spring the seed germinates and

penetrates the twig at the base of the needle. For the next 2-4 years, the parasite grows within the host tissues, developing a root-like system within the inner bark and outer sapwood, and causing the twig or branch to swell. Aerial shoots then develop and bear seed in another 2-4 years.

Dispersal of dwarf mistletoe seeds is limited to the distance the seeds travel after being discharged. From overstory to understory, this is usually 20 to 60 feet, but wind may carry them as far as 100 feet from the source. A rule of thumb is that the seeds can travel a horizontal distance equal to the height of the highest plant in an infected tree. There is some evidence that long distance spread of dwarf mistletoe is occassionaly vectored by birds and animals.

Vertical spread within tree crowns of most dwarf mistletoes is limited to less than one foot per year because of foliage density. Because of the thin crowns of Gray pine, however, the vertical rate of spread has been measured as being greater than 2 feet per year. This rate of spread equalled or exceeded the rate of height growth of infected trees.

Dwarf mistletoes are easy to identify because they are generally exposed to view within a tree's crown. Signs of infection include the yellow-green to orange mistletoe plants, basal cups on a branch or stem where the plants were attached, and detached plants on the ground beneath an infected tree. Symptoms include spindle-shaped branch swellings, witches' brooms in the lower crown, and bole swellings.

Western Pine Beetle

The western pine beetle, Dendroctonus brevicomis, breeds in the main bole of living ponderosa and Coulter pine larger than about 4 inches dbh. Normally it breeds in trees weakened by drought, overstocking, root disease, dwarf mistletoe or fire.

Adult beetles emerge and attack trees continuously from spring through fall. Depending on the latitude and elevation, there can be from one to four generations per year. The generations are difficult to distinguish because the prolonged period of initial attack and re-emergence of parent females to establish additional broods causes considerable overlapping of the generations.

Initial attacks are made about mid-bole and subsequent attacks fill in above and below. Pheromones released during a successful attack attract other western pine beetles. Attacking beetles may spill over onto nearby apparently healthy trees and overwhelm them by sheer numbers. Pitch tubes and red boring dust are indications of successful attacks.

Adults bore a sinuous gallery pattern in the cambium and the female lays eggs in niches along the sides. The larvae feed in the inner bark for a short distance and then turn into the outer bark to complete development.

Bluestain fungi introduced during successful attacks probably contribute to the rapid mortality associated with bark beetle attacks.

Woodpeckers, predaceous beetles and low winter temperatures cause natural control. Silvicultural activities that result in rapid, vigorous tree growth increases tree resistance and prevents mortality. Individual high value trees undergoing a temporary reversible stress, such as drought, can be protected for up to a year by applying insecticides to the bole.

Red turpentine beetle

The red turpentine beetle, Dendroctonus valens, occurs throughout California and can breed in all species of pines. It normally attacks injured, weakened or dying trees and freshly cut stumps. The adults are attracted by fresh pine resin. They often attack wounded trees in campgrounds or following logging, trees scorched by wildfire or prescribed burns, lightning-struck trees and root-diseased trees exhibiting resinosis.

Attacks usually occur at the soil line or root crown and are characterized by a large reddish pitch tube at the point of entry. On severely stressed trees or during periods of drought, attacks may occur underground on the main roots up to 15 feet from the bole and also on the bole to a height of 10 feet. If an attack is successful, the adults excavate an irregular gallery in the cambium and the female lays eggs along the sides. The larvae feed in a mass and destroy an area of cambium ranging from 0.1 to 1.0 square feet. Attacks do not always kill trees but may predispose them to attack by other bark beetles. Repeated or extensive attacks by the red turpentine beetle can kill pines.

Attacks occur throughout warm weather and peak at mid-summer. The number of generations varies from two years for a single generation at the coldest portions of its range to two or three per year in the warmest.

Attacks can be minimized or prevented by avoiding soil compaction and injury to standing trees during logging or construction and also by insecticide application to high value trees.

California flatheaded borer

The California flatheaded borer, Melanophila californica, principally attacks Jeffrey and ponderosa pines, although it may be found in other pines including Coulter and knobcone pines.

It is most severe in stands located on sites where environmental stress is common. Decadent or unhealthy trees are most frequently attacked, along with an occasional top of a thrifty, vigorous tree.

Eggs are laid in bark crevices of the host tree. Newly hatched larvae penetrate directly through the bark to the phloem. Here the larvae may feed from a few months to 4 years without any apparent effect on the host tree. Should host vigor and larval abundance not allow them to succeed, the larvae cut very short galleries before they die. These galleries do not seriously injure the tree and are overgrown by the cambium. Should conditions be, or become, favorable for the larvae and unfavorable for the tree, the larvae develop rapidly and destroy the cambium.

Although this insect can kill trees weakened by dwarf mistletoe, root disease or climatic stress, its primary importance is rendering trees increasingly susceptible to bark beetles.

Pine engraver beetles

Pine engraver, Ips spp., attacks have been recorded on most species of pines in California. These beetles kill saplings, poles and sawtimber up to about 26 inches dbh and the tops of even larger trees. Attacks on live trees are usually limited to trees which are suppressed, or stressed by dwarf mistletoe, root disease, drought, fire or the attack of other insects. If fresh slash is available in the spring, pine engravers may build up in an area and cause localized mortality or top killing by mid-summer.

Attacks are made with the coming of warm weather in the spring. Attacking males bore nuptial chambers in the inner bark and release a pheromone which attracts other beetles to the attack site. If many beetles are attracted, they may attack nearby trees and cause a group kill. Within a day or two of the attack by the male, two to five females enter the nuptial chamber and after mating, each female bores an individual egg gallery which lightly scores the sapwood. The size and pattern of the combined gallery pattern is often diagnostic of the species of Ips involved. The galleries are kept open by beetles pushing boring dust out through the entrance hole. Red boring dust collecting in bark crevices or spider webs is diagnostic of a successful attack. Eggs are laid in niches along the sides of the galleries. Larvae hatch from the eggs and feed in the phloem. They eventually pupate in cells at the end of their larval mines and transform to adults.

A new generation is produced in as little as 6-8 weeks in the spring to 4-6 weeks in mid-summer (August). Thus, several overlapping generations per year may be produced. The winter may be passed in any of the life stages of larvae, pupae, or adults, depending upon which Ips species is involved.

Outbreaks in standing, healthy trees are sporadic and of short duration, and are often associated with some temporary stress or shock afflicting the host species, such as drought or logging disturbance. Tree killing frequently occurs where green pine slash, which serves as breeding habitat is left untreated during spring and summer. To be suitable as pine engraver breeding habitat, pine slash must have bark from 1/8 to 1 inch thick (usually 3 to 26 inches diameter), must have succulent cambium and must remain moderately cool during the development period.

Fresh pine slash caused by thinning, dwarf mistletoe control work, construction or winter storm breakage can be modified in a number of ways to make it unsuitable for pine engraver breeding. One approach to minimizing damage is to schedule slash-generating activities mostly between mid-July and late-December, when the slash has a high probability of drying out, heating up, or spoiling before the beetles can complete their development. Utilization of the cut material to the smallest possible diameter will minimize the amount of breeding material available to engraver beetles. If green pine slash must be created during the sring and early summer, slash treatments are available to prevent the buildup of pine engraver populations. Because pine engravers can complete

their development in about a month under ideal conditions, treatment should be carried out soon after cutting to be effective.

Slash treatment methods which generally work well include chipping, lopping and scattering slash in sunny areas to heat it up, crushing or mashing slash with logging equipment to make it unsuitable for pine engraver breeding, or piling and burning the slash within a month of cutting. Broadcast burning the slash might work if it could be done without damaging the residual stand. A method which has worked during the summer in hot climates is to pile slash in a sunny area and tightly cover the pile with clear plastic. If the temperature under the bark of slash in all parts of the pile reaches 120°F, all brood currently in the pile will be killed. Lower temperatures will not be effective and, where successful, this method will not prevent reinfestation of slash piles. Because most pine engraver attacks occur within a quarter-mile from the location where the beetles emerged, high value pines can be given some protection by removing fresh pine slash to areas which do not have pines.

Two practices which should generally be avoided are piling fresh pine slash without further treatment, and allowing slash to touch or remain near valuable leave trees.

Fir engraver

The fir engraver (Scolytus ventralis) attacks both white and red fir in California. Trees ranging in size from large saplings to overmature sawtimber are susceptible. Attacks can cause patch-killing of cambium along the bole, top-kill, or tree death. Top-kill or death occur most often in firs that have been weakened by root disease, dwarf mistletoe, overstocking, soil compaction, sunscald, logging injury, or drought. The fir engraver also breeds in slash and windthrown trees.

The fir engraver usually completes its life cycle in one year, sometimes two. Adults fly and bore into trees or green fir slash from June to September; larvae, pupae, and adults over-winter under the bark. Pitch tubes are not formed as they are with pine bark beetles; the usual evidence of attack is boring dust in bark crevices along the trunk and pitch streamers on the mid and upper bole. Trees colonized early in the summer may begin to fade by early fall, but those colonized later in the year usually do not fade until the following spring or summer, often after the beetles have emerged.

Ground squirrels and chipmunks in campgrounds

Rodent populations often increase in campgrounds because of increased food, water, and nestsites. Campers may encourage rodents by deliberately feeding them or leaving out garbage for them rather than disposing of it in rodent-proof containers. Where water is limiting, leaking faucets may provide a critical resource to rodents. Improperly built barriers can provide nestsites for ground squirrels and chipmunks.

Rodents are undesirable in campgrounds because they serve as reservoirs for human plague and other diseases, and because their burrowing activities can undermine roads and structures.

Barriers: Where rocks are used as barriers, they should be set 1/3 to 1/2 below the soil grade. Rocks set too shallowly will provide burrow sites for rodents. Logs and other wooden traffic barriers should be elevated 6 inches or more off the ground. Logs set on the ground or only a few inches above it will provide nestsites.

Concrete slabs: It is difficult to keep rodents from burrowing under concrete-slab buildings. To correct this problem on an existing slab, dig a 12 inch wide trench along the foundation completely around the building at a depth of about 8 inches or the depth of the slab, if shallower. Place an 8-10 inch wide strip of heavy gauge wire mesh at the bottom of the trench, anchor it firmly (e.g., with large staples fashioned of stiff wire), then backfill the trench with soil or gravel and pack firmly.

Even well-designed campgrounds may require periodic rodent control.

For further information, see

Marsh, R.E., T.P. Salmon, and W.E. Howard. 1981. Integrated management of rodents and other wildlife in campgrounds. USDA Forest Service, Pacific Southwest Region, Fisheries and Wildlife Management, Recreation Management, and Forest Pest Management Report No. 81-39. 126 pp.

APPENDIX B

GUIDELINES FOR TREATING SLASH TO REDUCE RISKS OF ENGRAVER BEETLE OUTBREAKS

USDA Forest Service
Forest Pest Management, Region 5

Complacency in slash treatment --

"The threat of outbreaks posed by insects breeding in residues is generally overrated. Graham (1922) and Craighead et al. (1927) long ago concluded that the insect menace posed by slash is more theoretical than real. Entomologists today generally agree. However, it is well to treat ips with respect for the pine engraver problem associated with the creation of slash is unpredictable. There are years when no trees are killed, despite suitable slash and lots of beetles. These same conditions in other years lead to unacceptable tree mortality. Therefore, it is best to follow recommended practices and not to grow complacent because one has 'lucked out' for a couple of years."

The critical factor appears to be the vigor of the residual green trees in late summer. There generally is no tree mortality when precipitation in April, May and June is normal or greater; an 'ips year' occurs when precipitation in those key months is below normal. That, at least, is what general correlations suggest." (Dolph 1971)

A question facing foresters is whether the beneficial aspects of engravers aiding in residue fragmentation outweigh the reasons for removing residues.

SLASH TREATMENT

Broad statements are not possible. Considerations to be taken into account are 1) species of tree, 2) character of slash, 3) species of insect involved.

Concern: 1) Slash attracting insects from the surrounding forest and concentrating them in the vicinity of the slash, where they kill living trees; 2) slash supplying breeding material for insects which emerge and kill mature standing timber or seedlings, saplings and poles.

The main concern is slash from PINE, SPRUCE and DOUGLAS-FIR.
The slash of fir, larch, redwood, hemlock, cypress, cedar and juniper either breeds insects of very little significance as tree killers, or the trees killed are so few or of so little value as to be of small economic importance.

Pine

BEST	All lopped and exposed to sun.	< # of beetles produced
|	Only vertical limbs lopped.	|
|	Unlopped.	|
WORST	Lopped and piled.	> # of beetles produced

Worst time to create slash -- January to mid-July.

A. Prompt Slash Disposal

Dozer trampling (crushing); disking and trampling = chopping
Chipping
Plastic "Greenhouse"
Lopping (limbing)
Lop and scatter
Burning
Burying
Removal

B. Prompt Slash Disposal Impractical

Where general slash disposal is impractical, scattering the slash into openings where it is exposed to direct sunlight dries it out faster, and dry slash is unsuitable for beetle development.

C. Green Chain Technique

A good pine engraver year is usually one in which:

a. the winter is abnormally dry,
b. warm weather lasts late into the fall and occurs early in the spring,
c. spring rains are few with long periods between what rains occur.

MATERIAL USUALLY NOT PRODUCING LARGE BROODS:

1. Lopped material less than 3 inches diameter
2. Very large logs
3. Material with bark > 1 in in thickness is seldom attacked (excluding unlopped tree tops).
4. Old, soured or partially dry slash. (The objective of slash disposal treatments is to create this type of slash before infestation).
5. Thinning slash is not particularly good breeding material, but it is often densely attacked. This aggregation of beetles can result in tree killing when the recent problems of severe competition and the shock of sudden exposure to full sunlight are compounded by drought.
6. Trees treated with silvicide and slash therefrom.

MATERIAL CONDUCIVE TO THE DEVELOPMENT OF LARGE BROODS OF ENGRAVERS.

1. Most productive -- stem portions of unlopped tree tops varying in basal diameter from 10-20 inches or more.
2. Piled green slash of any dimension.
3. Concentrations of freshly-cut slash on the ground in full or partial shade.
4. Unlopped tree tops and other slash and debris created from January through June.

5. Most important source of breeding material in logging slash is the main stem from about 3 inches and up.
6. The main stem of a top is potentially more dangerous than limbs, particularly if the limbs are severed.
7. Shading with miscellaneous logging debris will offset lopping and sunlight.
8. Slash 6 to 24 inches diameter cut after January 1.
9. Piled pine pulpwood or logs.
10. Pines girdled for understory release.
11. Branches and tops of pines broken off by snow.
12. Pines girdled by porcupines.
13. Suppressed pines.
14. Shaded slash and the underside of logs.

BEST MANAGEMENT PRACTICES.

Keep track of amount of slash laid down by windstorms
Check lightning stuck trees whenever a fresh strike is seen.
When practical, cut young-growth pine after 7/15.
Lop and scatter all slash -- expose main stem to sun.
Utilize to minimum top diameter practible.
Keep accumlations of slash or green logs away from living trees, and fell trees away from dense thickets of young-growth.
When necessary, kill broods by best means.
Prevent accumulation of felled material (avoid cutting practices, patterns, conducive to windthrow)
Alternate stand structure and species composition to reduce susceptibility.
Log infested and threatened stands -- 1st priority: stands with heavy populations and/or large volumes per acre.
Remove dead and infested trees from campgrounds before emergence.
Surveillance (monitoring) -- not treatment is necessary if there are few beetles. - reddish boring dust on upper surfaces and on ground under slash
- Y, I, or H-shaped egg galleries; Y-shaped most common.
- no pitch tubes
Salvage windthrows as soon as possible.
Residue treatments to minimize damage is most effective if applied before the thinning slash is attacked.
In high risk areas, such as campgrounds, use method(s) that prevent aggregation of many attacking beetles in proximity to residual trees.
Avoid trimming along power lines and other rights-of-way, running logging equipment over root systems of residual trees (designate skid trails), or other practices which may injure trees during periods of hot dry weather.
Destroy slabs from portable sawmills operating in forested areas.
Do not leave any ponderosa pine slash in a position that will prevent it from drying out quickly. When slash must be piled, plan to do it after mid-October, or treat by chipping or some other destructive method.
Intensive utilization and clean logging -- eliminate much of the slash and make it possible to more efficiently and effectively treat the slash in fuel and insect management.
Slash piled or bunched for burning or for wildlife habitat should be allowed to dry before the piling opertion.

AVOID THESE WORST MANAGEMENT PRACTICES:

Piling fresh slash in any season without further treatment.
Letting slash or green logs accumulate near living trees.
Piling bucked limbs and cull logs along any forested roadside for fuelwood without prior treatment.
Windrowing fresh slash without drying (or partial drying).
Sporadic cutting in the spring of the year, with the slash unlopped and unscattered.
Removal of infested material to developed areas where emerging beetles can attack high value trees that may be stressed by improper site manipulations.
Piecemeal treatments -- measures to suppress beetle populations in thinning residues will minimize damage only if applied comprehensively on a regular basis.
Piling fresh slash adjacent to standing trees.

Best recommendation: Prevent stagnated or highly competitive growth conditions in stands.

Brood Material --

Man-caused
- pine logging slash
- pines damaged during logging of other trees
- fire-damaged pines
- pine pulpwood or log piles
- right-of-way clearing slash
- pines girdled for understory release

Natural
- trees weakened by other insects or other factors
- branches and tops of pines broken off by snow
- pines girdled by procupines
- pines suppressed from competition
- diseased pines

Soils at field capacity at the beginning of the growing season will be nearly exhausted of moisture reserves by late July and early August if rainfall is below normal. Coincidentally, it is during this period that adult pine engravers are emerging at a fairly constant rate. However, moisture stress alone will not normally induce an outbreak. Stress must be coupled with brood material to provide the population increase necessary to produce tree killing.

Thinning after June 15: most available soil moisture is used and thinning will not provide any additional moisture for the residual stand. What you will get is increased soil temperatures and a higher evapo-transpiration stress.

Two situations which should be avoided at all seasons are piling fresh pine slash without further treatment, and allowing slash or green logs to accumulate near living trees.

California five-spined ips --

Beetles begin to emerge from spring-infested debris about the same time that trees first experience moisture stress and the result can be considerable tree mortality in nearby stands.

Even in areas where pines are few, pine slash can be heavily infested.

Literature Cited

Dolph, R.E. 1971. Oregon pine ips infestation from red slash to green trees. In D.M. Baumgartner (Ed.) Precommercial thinning of coastal and intermountain forests in the Pacific Northwest, pp. 53-62. Washington State University, Pullman, WA.